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JPRS L/9181

3 July 1980

USSR Report

CONSTRUCTION AND EQUIPMENT

(FOUO 7/80)

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USSR REPORT

CONSTRUCTION AND EQUIPMENT

(FOUO 7/80)

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METALWORKING EQUIPMENT

UDC 681.325.5-181.48:621.9-52

APPLICATION OF DIGITALLY CONTROLLED MACHINE TOOLS

Possibilities of Microprocessor Units

Moscow PRIBORY I SISTEMY UPRAVLENIYA in Russian No 11, 1978 pp 5-7

[Article by Doctor of Technical Sciences Ye. P. Balashov, V. B. Smolov, Engineers V. Ye. Kochetkov, G. Ya. Kuz'min, Candidates of Technical Sciences M. S. Kupriyanov, D. V. Puzankov, N. A. Smirnov: "Structural Principles of Digital Program Control Systems Based on Regular Microprocessor Structures"]

[Text] The mastery by Soviet industry of the production of large integrated circuits (BIS), in particular, microprocessor sets, is used as the basic prerequisite for mass introduction of all-purpose computer means into the digital program control systems (SChPU). This will permit a sharp reduction in the nomenclature of the developed SChPU, an increase in the efficiency and quality of the control process, and it will insure its increased reliability and viability. The complex approach to the planning and design of the SChPU must take into account not only the possibilities afforded by the microprocessor units, but also the requirements imposed, in turn, on them by the actual technological processes. The purpose of this article is the investigation of the general principles of construction of SChPU based on the microprocessor units, the requirements which must be satisfied by computer means organized on the basis of them.

Basic Configuration of the SChPU

By the basic configuration we mean a system which contains minimum hardware and software required for realization of the process of controlling the given technological process equipment.

The analysis of Soviet and foreign experience in designing SChPU for metal cutting equipment indicates that the basic configuration (Fig 1) includes the following basic modules:

The operator panel PO designed to give all of the operating modes of the system and also for input, editing of the program and displaying the required information (it can be structurally made built into the SChPU or remote);

The buffered memory for the machining program BPPOD required to store the machining program (or a part of it);

The correction memory PK for storing corrections for the length and radius of the tool, shifts, error compensation corrections of the mechanical system of the object, and so on;

The editing information memory PRI where the information introduced in the editing mode for error correction or altering the machining program is stored;

The data preparation program memory PPPD in which the dispatcher program, the package of programs for packing and conversion of information, data preparation (the algorithms for calculating the equidistant, interpolation, and so on) are stored;

The processor P -- the basic computing element which also controls the operation of all of the system modules;

The timer T for giving the time intervals of the system operating on a real time scale;

The auxiliary panel VP which duplicates certain basic functions of the panel PO and is located directly on the object of control (absent if the PO panel is remote);

The external device VU which performs the function of output to the SChPU and storage of the part machining program library in ISO language;

The module for communications with the object of control BSOU required to execute the process commands;

The drive control module BUP which provides for coupling the micro-interpolator or the processor to the drive of the control object;

The microinterpolator Mi which converts the increments calculated by the processor to the output frequency (it can be absent, for example, when using the BUP module with coded information reception);

The object of control OU.

The interaction of all of the system modules is basically realized by means of three buses: address A, data D, control U. The state of the object of control the position of the terminal breakers, emergency situations, and so on) is recorded by the feedback in the BSOU module.

The function of the system depends on the modes which are given from the PO or VP panel, and they are determined to a great extent by the technological process. The most widespread modes are automatic and frame by frame [for the processing of one frame of the program, frame search, preset (manual input), editing and manual control regime]. The basic and most complex (requiring maximum output capacity of the processor) mode is automatic.

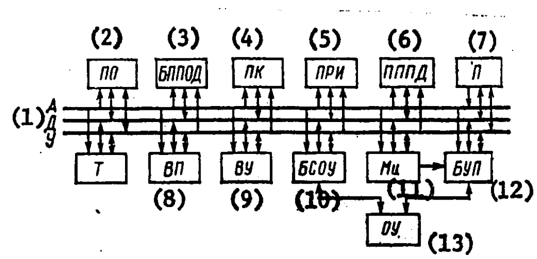

Figure 1. Base configuration of the SChPU

Key:

1. ADU
2. PO
3. BPPOD
4. PK
5. PRI
6. PPPD
7. P
8. VP
9. VU
10. BSOU
11. Mi
12. BUP
13. OU

In Fig 2 we have the algorithm for the functioning of the SChPU of basic configuration in the automatic mode for the case where the BPPOD memory (Fig 1) is designed for only one frame of the program, and the photo-reader (FSU) is used as the VU device.

In order to analyze the functioning algorithm, let us introduce the concept of the computer cycle by which we mean the time defined by the expression $T_c=t_1+t_2$, where t_1 is the time required for the processor to perform the mandatory functions providing for processing of the trajectory and the technological process commands; t_2 is the time expended on realization of the functions (completely or partially) not mandatory for the given cycle. The calculation cycle is determined considering the following factors: the characteristics of the feed drives, the speed of the processor, the time interval of the controlling digital signals received and output to the control object, the range of realized feed rates, the presence or absence of interrupt modes, and so on. From the algorithm presented in Fig 2 it follows that the calculation cycle can be determined by the performance of one of the following operations: the fragment A; the fragment A and input; fragment A and data preparation; data input and preparation. The distribution of the resources of the commutation cycle depends on the information in the frame, the operating speed of the FSU, the frequency of appearance of the signal GMi (adaptation with respect to speed).

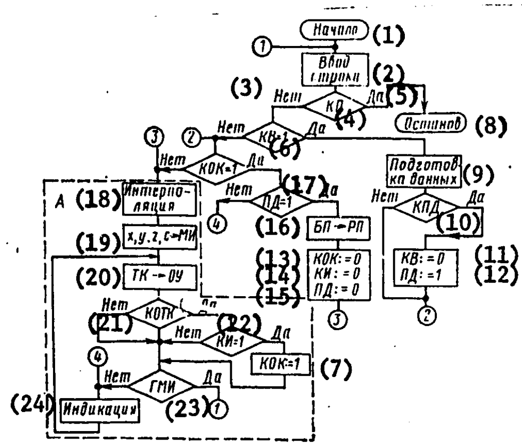

Figure 2. Algorithms for operation of the SChPU with memory size of the BPPOD for one frame:
KP -- end of program; KV -- end of frame input; KOK -- end of frame processing; PD -- data preparation attribute; KPD -- end of data processing; x, y, z, c -- increments with respect to the coordinates which are output to the corresponding BUP modules (see Fig 1) -- in the required cases through the microinterpolators; TK -- technological process command; KOTK -- end of processing of the technological command; KI -- end of interpolation; GMi -- ready condition of the Mi device; BP -- buffered memory [memory region of the BPPOD (see Fig 1), where the data are prepared]; RP -- operating memory (region of the BPPOD memory in which the data prepared for processing are stored); A -- fragment of the algorithm which processes the trajectory, the technological command and display; OU -- object of control

Key:

1. Begin
2. Row input
3. No
4. KP
5. Yes
6. KV=1
7. KOK=1
8. Halt
9. Data preparation
10. KPD
11. KV: =0
12. PD: =1
13. KOK:=0
14. KI:=0
15. PD:=0
16. BP→RP
17. PD=1
18. Interpolation
19. x,y,z,c→MI
20. TK→OU
21. KOTK
22. KI=1
23. GMI
24. Display

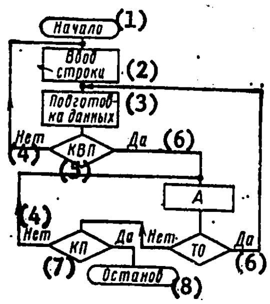

Figure 3. Algorithm for operation of the SChPU with memory size of the BPPOD for the entire program (provisional notation in Fig 2 is used):
KVP -- end of program input

Key:

1. Begin
2. Row input
3. Data preparation
4. No
5. KVP
6. Yes
7. KP
8. Halt

For the system shown in Fig 1, the development of a dispatcher -- the basic element of the software (MO) is a labor-intensive process, for in this case the resource distribution of the computation cycle and the interaction of the modules depend on many conditions, the analysis of which requires the expenditure of software and memory. The internal software is simplified significantly if the system has a memory (in our case the BPPOD memory) designed for the entire program. During input of the program this makes it possible to carry out all of the data preparation (the prepared program occupies one-third the volume that the initial program occupies in ISO language), include the FSU in the operation only when inputting the program (in this case the FSU operates in a continuous mode and not in the start-stop mode), as a result of which the energy consumption and heat release decrease, the operating reliability of the entire system as a whole increases, later on the expenditure of resources of the computer cycle is insured only for fulfillment of the fragment A. If the possibility of the input of new corrections is provided for when the technological halt TO comes with confirmation, then from this time some recalculation of the data is required for the remaining section of the trajectory. The algorithm for the functioning of the SChPU with BPPOD memory is presented in Fig 3 for the entire program.

Multiprocessor Configuration of the SChPU

In the case of servicing the complex technological equipment SChPU (for example, the machine tool with two benches, on one of which the preparatory operations are conducted, and on the other, direct machining or a machine tool with a robot) the number of parallel-executed procedures

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increases, which requires higher output capacity of the processor and the presence in it of a developed interrupt system. The indicated complication of the requirements complicates the introduction of the microprocessors into the SChPU and makes the use of the SChPU configuration presented in Fig 1 ineffective. The high "parallelism" of the functions realized by the SChPU gives rise to the application of the multiprocessor configuration with problem orientation of each of the processors.

Fig 4 shows the two-processor configuration of the SChPU in which the processor P1 provides for program input and data preparation, and the processor P2, the solution of the trajectory problem (fragment A). The package of applied programs of the processor P2 is located in the memory for processing the current frame POTK. The interaction of the processes is realized by means of the AKK device for coupling the adapter—channel-channel means, through which for normal functioning of the entire system the processor P1 transmits the information prepared for processing to the processor P2.

The algorithms for the functioning of the two-processor SChPU are presented in Figures 5 and 6; in Fig 5 we have the algorithm for the operation of the processor P1, and in Fig 6, the algorithm for the operation of the processor P2. The data transmission time is determined by the attribute PD which is established by the processor P1, and it is cleared by the processor P2. The functioning of the processor P1 is presented for the case where the BPPOD memory is designed for one frame of the program. If the BPPOD memory is designed for more than one frame, the processor P1 can perform a number of the functions (monitoring, diagnosis and so on). The application of the multiprocessor organization of the system permits, in addition to the use of processors with simplified internal software and structure by comparison with the analogous data of the processor of the single-processor system, also an increase in the reliability of the functioning of the SChPU. This is achieved as a result of the fact that on failure of one of the processors its functions can be realized by another processor, and the system will operate with a reduced, but admissible quality level.

The number of processes in the system can be increased with further decomposition of the functions. Thus, for example, it is possible to distribute the execution of the function of the processor P1 among the two processors, one of which will input the information, pack it and preprocess it, and the other will prepare the data.

Problem Orientation of Processors for SChPU

The problem orientation of the processor is determined by the specialization of its hardware and software, and it is carried out for more effective realization of the functions of the system. As follows from the algorithms presented in the article, the basic functions realized in the system are data input to the BPPOD memory and packing of it; data preparation; interpolation; realization of the process commands; and display. Let us consider the most important paths of specialization of the hardware and software, being oriented toward the enumerated functions.

The information is introduced byte-by-byte, which determines the byte organization of the processor. Inasmuch as the input procedure does not vary as a function of the orientation of the SChPU for specific equipment, it is expedient to realize it on the microprogram level. This requires, first of all, the microprogram access to the BPPOD memory cells, secondly, insurance of flexible masking of the bits of the byte, thirdly, the presence of a sufficiently large microprogram memory. It is desirable to introduce microinstructions which reflect the nature of the conversion algorithm, the nature of the permutation of the tetrads in the byte, the setting and clearing of flags, and so on.

When preparing the data, the operands 3 bytes long are used. Consequently, the processing can be carried out in series-parallel (byte-by-byte) or in parallel (depending on the speed requirements). For this reason the structure of the processor must provide for an increase in word length. In order to simplify the programming and check out the algorithms for data processing and interpolation it is expedient to execute the mentioned algorithms on the program level, which also guarantees the continuity of the developments and invariance of the package of applied programs in the element base.

When using the BUP module in the system without coded information reception to control the drive, a digital integrator is required, the word length of which is determined by the word length of the calculated increment. In turn, the word length of the code transmitted to the digital integrator depends on the duration of the calculation cycle and also the maximum data processing rate realized in the system.

The process instructions are executed in accordance with the execution of the logical algorithms by the functioning of the relay-contact modules of the process equipment. The replacement of the unreliable relay-contact modules which occupy a large volume by the table or table-algorithmic processors based on integral memory with logical nature of the data processing significantly increases the regularity of the SChPU as a whole, its reliability and effectiveness.

The results are displayed by output of the information required by the operator to the display elements (and it is also possible to convert the information from one number system to another). For the performance of such functions which do not depend on each other in time, it is expedient to have specialized processors in the system (in the majority of cases, table-algorithmic).

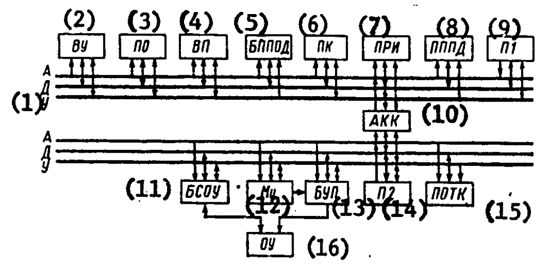

Figure 4. Two-processor configuration of the SChPU (the notation is the same as in Fig 1)

Key:

1.	ADU	10.	AKK
2.	VU	11.	BSOU
3.	PO	12.	Mi
4.	VP	13.	BUP
5.	BPPOD	14.	P2
6.	PK	15.	POTK
7.	PRI	16.	OU
8.	PPD		
9.	P1		

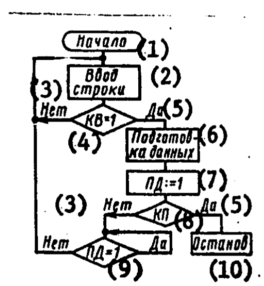

Figure 5. Algorithm for the operation of the processor P1 (for the notation see Fig 2)

Key:

1.	Begin	6.	Data preparation
2.	Row input	7.	PD:=1
3.	No	8.	KP
4.	KV=1	9.	PD=1
5.	Yes	10.	Halt

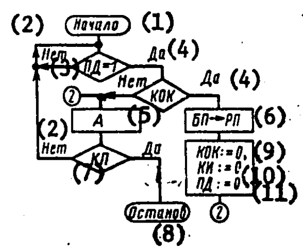

Figure 6. Algorithm for the operation of the processor P2 (the notation is the same as in Fig 2)

Key:

1. Begin
2. No
3. PD=1
4. Yes
5. KOK
6. BP→RP
7. KP
8. Halt
9. KOK:=0
10. KI:=0
11. PD:=0

The approach based on the most complete use of the functional possibilities of the memory and also the construction of algorithmic structures with the application of multifunctional moduli with regular structure permits organization of the computation means for the SChPU with satisfaction of the enumerated requirements. The realization of the moduli in the form of BIS [large integrated circuits] provides a basis for discussing the micro-processor structures, which primarily determines the specific technical realization of the computer structure. An example of this type of structure is the family of BIS "Intel 3000" (the Intel Company, USA). The regular microprocessor structures permit not only composing of the processor with the required structure and architecture and at the same time, problem orientation of it, but also the use of individual moduli for the execution of other modules (for example, the Mi, BUP and other modules).

The indicated approach offers the possibility in the final analysis of organizing SChPU based on two types of modules: memory and microprocessor BIS. In conclusion, it must be also noted that the structure of the SChPU based on the microprocessor regular structures corresponds to the observed trend toward modular construction of the system, which simplifies the possibility of altering its functions and indexes, heat transfer, placement with respect to the object of control, prevention and maintenance.

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Broad Application

Moscow PRIBORY I SISTEMY UPRAVLENIYA in Russian No 11, 1978 pp 8-9

[Article by Engineers V. V. Vasil'yev, I. G. Mazilkin, A.V. Plotnikov, A. L. Simakov: "Broad-Application Digital Program Control Devices Based on Microprocessors"]

[Text] The technical problem of the digital program control devices achieved in 1977 for the series machine tools with respect to composition of the executed control functions basically corresponds to the world level of the class NC digital program control means [1]. However, in the series digital program control devices (UChPU) there are a number of deficiencies, in particular, the comparatively low level of the element base and the presence of a large number of contact joints, which lowers the reliability of the devices; the process of reading out the working program (RP) from the punch tape, which is also the basic source of failures of the UChPU; the introduction of changes in the RP by the processing results requiring a great deal of time and complex with respect to execution.

In addition, the series UChPU is characterized by all of the deficiencies of the devices with rigid structure which can be eliminated by the application of programmed means, which until the appearance of microprocessors (MP) ard the microcomputer was held up by arguments of an economic nature.

High reliability, low cost and low intake power, computation power on the minicomputer level are promoting broad introduction of the microprocessor means (MP-means) into the UChPU of the metal cutting machines (MRS). The program method of execution of the set of control algorithms and storage of the RP in the ready-access memory will permit improvement of the technical-economic parameters of the machine tool system -- the UChPU and significantly expand the set of functions executed by the UChPU; increase the volume of introduced corrections; perform checkout and editing of the RP directly on the UChPU; expand the possibilities of the RP by introducing standard cycles and subroutines; to find new areas of application of the specific model of the UChPU by specialization of software (MO); a decrease in design time and volume of documentation, to simplify checkout, servicing and repair of the UChPU; perform program checkout of the machine tool shafts and compensation for clearances.

The application of the MP-means is facing the developers with a number of qualitatively new goals, first of all, the goals of selecting the microcomputers and the development of the internal software of the UChPU. The solution of these problems requires algorithmic analysis of the functions of the UChPU and simulation of them on a microcomputer.

The given article is devoted to discovery of the specific features of the UChPU MRS set of algorithms connected with the application of the MP-means and estimation of the possibilities of certain MP and microcomputers when executing the problems of digital program control. The requirements of the microcomputers designed for operation in the CNC system are defined also in the article.

It is known [1] that the main goals of the UChPU are the forming, process support, adaptation, and so on.

The forming goal which consists in realizing the given law of displacement of the tool with respect to the machine part in the general case consists of the following problems: the introduction of a correction and calculation of the equidistant; maintaining the constancy of the peripheral velocity and linear variation of it on changing the feed magnitude; interpolation (linear, angular, thread cutting); high-speed control.

The problem of the process support is solved by the transmission of instructions (in ISO language) M, S, T to the electrical automation of the machine tool in the simplest case either by conversion of the indicated commands into series of signals for controlling the contactors and relays considering their response time.

Adaptation is the reaction of the UChPU to the effect of external factors: from emergency signals to optimization of the working processes.

Other goals include the introduction of the RP, the preparation of the frame, organization of communications with external devices, and so on.

Fig 1 shows one of the basic versions of the organization of the solution of the UChPU problems. Two parallel branches [the ith and the (i-1)st frames] reflect the parallelness of the input and the preparation of the next frame in the buffer memory (BP) and the processing of the latter. The cycle for processing the configuration (control of the peripheral velocity, interpolation, drive control) can consist in the development of both a unit displacement (step) in the case of a stepping drive (ShP) and package of steps for interpolation to a constant frequency carrier or the time interval for interpolation with constant increment in the case of a servodrive (SP).

The problems of controlling the angular velocity, the interpolation and the control of the drive also can be solved in parallel. The problem of developing the technological process can be carried out in series and parallel with the configuration processing cycle, which is determined by the code of the commands M, S, T.

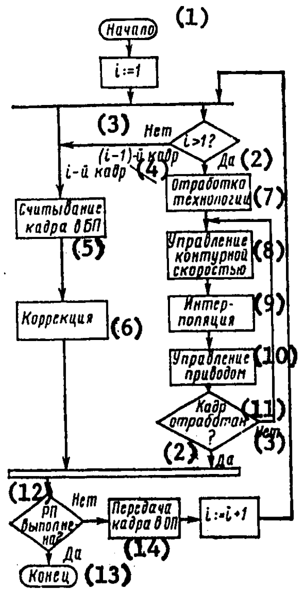

Figure 1. Organization of the solution of the UChPU problem: OP -- ready-access memory

Key:

1. Begin
2. Yes
3. No
4. (i-1)-st frame
5. Reading the frame in the BP
6. Correction
7. Technological processing
8. Control of the peripheral velocity
9. Interpolation
10. Drive control
11. Frame wornout
12. RP [executed?]
13. End
14. Frame transmission to OP

The adopted language for including the RP is the language corresponding to the recommendations of the ISO and the All-Union State Standard 20999-75 and characterized by the decimal number system, the address system of command using the alphanumeric symbols, the combination of commands into modules (frames), and variable frame composition and command length.

For the modern level of development of the UChPU, accuracies of 0.001 mm, maximum displacements of 9999.999 mm, feed rate of 0.01 to 10000 mm/min, fast speed 15-18 m/min are characteristic.

The set of problems of the UChPU have the following specific (if we are talking about the application of MP-media) peculiarities.

I. The difference in nature of the problems with respect to composition of the operators and the requirements on the technical execution;

1. The development of the configuration is basically a calculation problem in which the operations are performed with numbers with a word length of up to 25 bits. The minimum cycle time t_{cycle} for developing the configuration is defined as the value which is the inverse of the maximum frequency f_{max} of the ShP or the carrier frequency f_H for the SP. For modern drives f_{max}=16 kilohertz [1], f_H=200 to 1000 hertz. Thus, the value of $t_{cycle\ min}$ is 62.5 microseconds for the ShP or 1-5 milliseconds for the SP.

2. In the problem of developing the process, basically a logical process, operations are performed with data in 1-8 bits, and there is an admissible solution time 0.1-40 sec determined by the response time of the relay and the contactors.

3. In the other problems data are used in 1-32 bits, but these problems are solved in the nonoperative mode.

II. The variety of types of input and output data with respect to the communications procedure and methods of representation.

III. The relative "freedom" in the selection of the order of execution of the UChPU problems.

The last characteristic, which permits solution of the problem of the UChPU in parallel and in series, demonstrates the possibility of constructing the UChPU both decentralized and centralized. For example, the parallelness of the solution of the problem presupposes the presence of a decentralized structure where different problems are executed by different modules constructed on fixed or programmable logic.

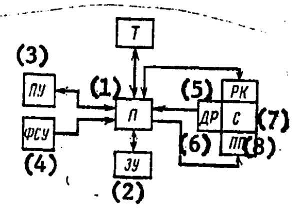

Figure 2. Centralized Structure of the UChPU:
PU -- control panel; FSU -- photographic reader; T -- time; П -- processor; ZU -- memory; S -- machine tool; DR -- thread cutting sensors; PP -- feed drive; RK -- relays, contactors

Key:

1. P
2. ZU
3. PU
4. FSU
5. RK
6. DR
7. S
8. PP

Figures 2 and 3 show the centralized and decentralized structure of the UChPU, respectively, used when determining the possibilities of MP-media. In the case of the centralized structure of the UChPU, the set of algorithms must be executed in series, which implies the necessity for selecting the processor insuring realization of the worst version of the combination of algorithms (with respect to time having a universal system of instructions for active solution of problems of any nature).

For decentralized structure, the requirements on the technical specifications of the processors are lowered significantly, and the possibility of the specialization of the latter as applied to the nature of the solved problem appears.

The UChPU problems are simulated with the following restrictions: a study is made of the centralized type UChPU; the method of interpolation by the approximating function was used; it was proposed that in the composition of the software of the UChPU there is a translator of the work program from the code of the ISO language to the internal representation characterized by two fixed formats of instructions and the binary number system, which gives a decrease in the required memory size under the RP; the software of the UChPU includes the dispatcher program which provides for the general organization of operations.

The simulation and analysis were realized on the basis of the controlling algorithms of the UChPU organized for the solution of them on a microcomputer (Fig 4).

For simulation of the digital program control problems, the MP-means were selected which have different technical specifications and encompass the MP-devices manufactured with the application of all of the modern forms of the process and produced both in the form of the sets of MP of the BIS and in the form of the microcomputer.

A study was made of the sets of BIS and microcomputers widely discussed in the literature (Intel 8080, Intel 3000, LSI-II made in the United States, and so on). In the table the results are presented on the most important algorithms of the digital program control devices. Under the condition of insuring the required accuracy the criteria for the comparison of the microcomputers was the maximum time T_{lim} of execution of the programs (for the UChPU functions in real time) and the memory size V_{ZU} as the parameter which to a decisive degree influences the cost of the microcomputer.

The following algorithms were considered to be important: those in which problems are executed in real time with the least admissible solution time; those having the greatest complexity, that is, the longest branch of the algorithm in the selected system of operands; those processing the information of greatest word length.

Algorithm	Intel 8080		LSI-II		Intel 3000	
	V_{ZU} in bytes	T_{lim} in microseconds	V_{ZU} in bytes	T_{lim} in microseconds	V_{ZU} in bytes	T_{lim} in microseconds
Circular interpolation	374	550	110	177	-	-
Linear interpolation	330	460	106	159	345	20
Thread cutting	184	355	142	270	-	-
Control of the peripheral velocity	120	200	80	140	198	10
Control of the steppin drive	38	45	108	147	246	10

The investigation of the problems of the UChPU with respect to the mentioned attributes made it possible to isolate the most important goals with respect to execution of the microcomputer: the circular interpolation, linear interpolation, thread cutting, the control of the peripheral velocity, control of the stepping drive.

The analysis of the specific nature of the problems of the UChPU and the results of simulating them on some of the MP devices offered the possibility of formulation of the properties of the microcomputer oriented toward application in the UChPU of the CNC type.

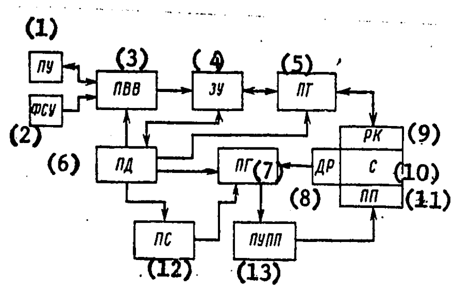

Figure 3. Decentralized structure of the UChPU:
PVV, PT, PD, PG, PS and PUPP -- the input-output, technology, dispatcher, configuration velocity processors, respectively, the control of the feed drive (the remaining notation is the same as in Fig 2.

Key: 1 -- PU; 2 -- FSU; 3 -- PVV; 4 -- ZU; 5 -- PT; 6 -- PD; 7 -- PG; 8 -- DR; 9 -- RK -- 10 -- S; 11 -- PP; 12 -- PS; 13 -- PUPP

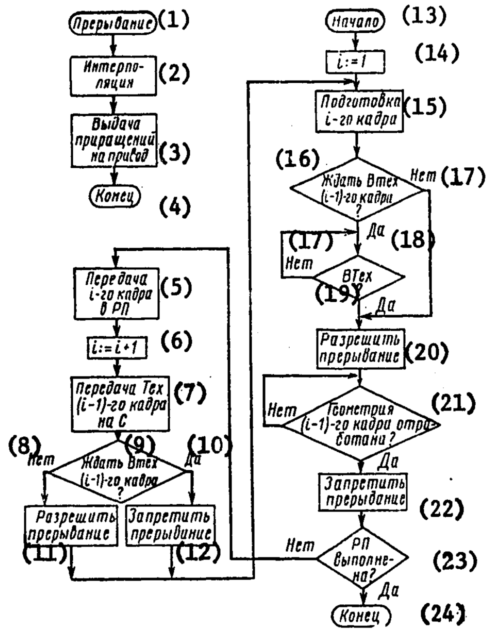

Figure 4. UChPU algorithm used for simulation and analysis: Tekh -- technology; VTekh -- execution of the process; S -- machine tool

Key:
1. Interrupt
2. Interpolation
3. Output of increments to the drive
4. End
5. Transmission of the i-th frame to the RP
6. i:=i+1
7. Transmission of the Tekh (i-1)st frame to the S [machine tool]
8. No
9. ~~Expect~~ V_{tekh} of the (i-1)st frame?
10. Yes
11. Permit interrupt
12. Prevent interrupt
13. Begin
14. i:=1
15. Preparation of the i-th frame
16. Wait for V_{tekh} of the (i-1)-st frame
17. No
18. Yes
19. V_{Tekh}
20. Permit interrupt
21. Configuration of the (i-1)st frame developed?
22. Prevent interrupt
23. RP Wait for
24. End

1. The speed of the microcomputer must be within the limits of 100,000 to 1,000,000 operations per second (the high value insures a larger number of simultaneously controlled coordinates and greater magnitude of feed).

2. The capacity of the ready-access memory (14-16)K bytes is sufficient to store the programs for the internal software and the programs of the user up to 999 frames long.

3. The variable ISO command length determines the necessity of byte-by-byte organization of the ready-access memory by the argument of memory economy.

4. The presence of variable length and composition of the frame and also variable length of the ISO instructions and the variety of formats of the external signals, for processing of them it is necessary to introduce the means of working with words of 1, 2, 3 and 4 bytes and 1 bit into the microcomputer instruction system.

5. In order to decrease the service time and increase the admissible feed rate, direct access to the memory is required on the part of the MRS drives.

6. The presence of from 8 to 16 general-purpose registers 24 bits long permits significant decrease in the solution time of the forming problems which make up the basic part of the controlling algorithms of the UChPU.

7. The presence in the software of means of translation and editing of the ISO language offers the possibility of greatly decreasing the required memory size of the user subroutine and provision for checking them out directly in the UChPU-machine tool system.

8. The presence of individual modules solving the most important problems of the UChPU will, on the one hand, permit a significant reduction in the requirements imposed on the microcomputer, and on the other hand, expansion of the class of functions by increasing the number of simultaneously controlled coordinates and complication of the trajectories of the displacement of the tool bit.

9. As a result of the developed interrupt system it is possible to simplify the software, more efficiently to load the microprocessor and organize the parallel operations of the external devices.

The formulated requirements can be used as the basis for a comparative analysis of the MP-means planned for use in the UChPU or serve as a basis for developing a specialized microcomputer or a set of MP BIS.

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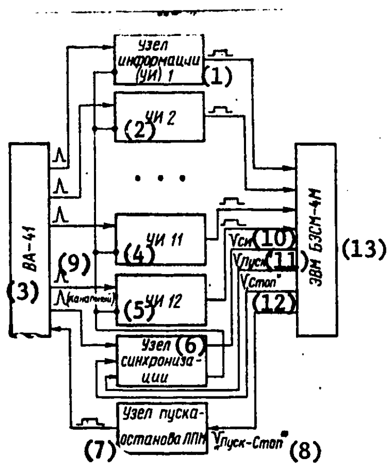
UDC (681.3.06-52).001.42

Practical Reliability

Moscow PRIBORY I SISTEMY UPRAVLENIYA in Russian No 11, 1979 pp 34-35

[Article by Candidate of Technical Sciences S. Ye. Miroshnik, Engineer V. B. Ioffe: "Study of the Reliability of the Functioning of the Digital Program Control Device Under Industrial Conditions"]

[Text]



Key:

1. (UI)-1 information unit
2. UI 2
3. VA-41
4. UI 11
5. UI 12
6. Synchronization unit
7. LPM start-stop unit
8. Start-stop
9. (channel)
10. V_{SI}
11. V_{start}
12. Vstop
13. BESM-4M computer

Usually the resultant information recorded on the magnetic tape or the accumulator is reproduced by the VA-41 device and is accumulated in the form of graphical information which then is converted to digital form and after punching on the carrier the information is introduced into the computer for processing. This information processing unit is labor-intensive and leads to significant errors.

The device for input of information to the BESM-4M computer recorded on the K-60-41 accumulator tape has been manufactured and operated since 1974. This device which is made up of the reproduction bay VA-41 and the coupler to the computer is connected to the BESM-4M computer through a plug which is designed for connecting the reserve circuit of the card input to the number 2 or 3. The device is controlled by the computer by instructions of two types: the start-stop motor of the tape drive mechanism (LPM) VA-41 and the information read.

The functional diagram of the coupler with the computer shown in the figure includes 12 like assemblies for the reception, intermediate storage and output of the "bit" information to the computer picked up from the tape, the synchronization unit and the start-stop units of the motor of the VA-41 tape drive mechanism. All of the assemblies of the coupler with the computer are constructed on the basis of the reserve elements of the BESM-4M computer.

The operation of the device in combination with the computer takes place as follows: before the beginning of operation of the program the control of the VA-41 tape drive mechanism must be set to the "remote" and "reproduction" positions. During operation of the program the start command of the tape drive motor is used to switch on the motor of the VA-41 tape drive mechanism. On expiration of the time required for run-up of the motor (~1 second), the recorded information read command is fed. By the "read start" signal, the synchronization device is switched on, which at this time permits the feed of the potential information signals to the computer. The clearing of the information after transmission to the computer is realized by the channel call switches delayed in the synchronization unit. It plays the role of the synchropulse SI in the computer. After the reception of the required number of codes in the computer given in the read command by the initial and final addresses of the ready-access memory, the "read stop" pulse halts the reception of the information. Then the "stop" command was fed to the motor of the tape drive mechanism. The motor stops, and the computer begins to process the received information. The mode for the reception of one code and its processing in the time interval before reception of the next code is also possible.

The recording of the processes on the tape of the K-60-41 storage element is accomplished in zones of defined length. The recognition of the required zone is by program means when processing the information on the computer.

The described device is a component part of the information measuring system which operates with separation with respect to place and time between receiving the initial material and processing of it. The use of the device permits a significant reduction in the initial data preparation time. The time saving is achieved as a result of the exclusion of the necessity for processing the oscillograms for conversion of them to digital form and the conversion of the digital material to the form suitable for computer input, which offers the possibility of a significant reduction in the time and the means for obtaining the results of the investigation or testing different machines and equipment.

The cost benefit of using the information measuring system which includes the described input device is ~50000 rubles per year.

An important step of the program with respect to insuring reliability of the digital program control devices (UChPU) for the metal cutting machine tools is analysis of the reliability and the effectiveness of the functioning of the UChPU under industrial operating conditions. In the organized information gathering system on the reliability of the UChPU the basic method is operation under monitoring. However, for the UChPU, the manufacture of which has only started, simultaneously with the organization of the latter it is expedient to perform direct operating studies by the efforts of the reliability of the podrazdeleniye workers. The duration of the operating studies is 2 or 3 weeks at each investigated enterprise. The information is entered on the primary data collection cards on the operation of the UChPU. All of the past failures, the time of beginning and end of repairs (with corresponding isolation of the repair time) and the daily work time of the UChPU are recorded.

In 1975-1977, the LEMZ Production Association jointly with the users studied the operation of the UChPU in industrial operation. The goals of the study were determination of the actual reliability indexes of the UChPU, the modules and assemblies limiting the reliability of the UChPU, and the correction defects.

The devices in the microelectronic execution of the N22, N33, N55 types and the devices on a digital base of the "Kontur 2PT-71" type manufactured in 1974-1976 were subjected to study. Information was gathered on 156 UChPU from 24 user enterprises. The entire data file was processed in accordance with the normative materials.[1] The following basic results were obtained.

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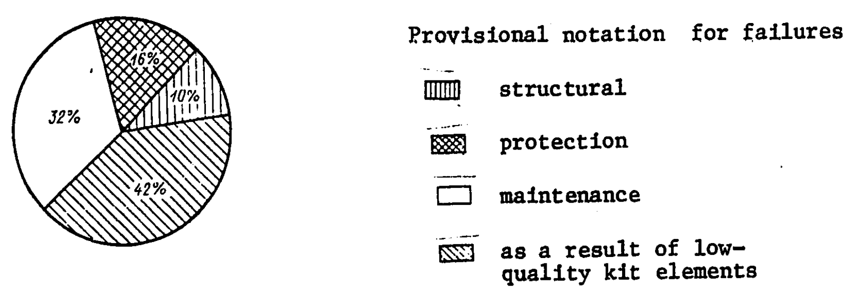
1 All-Union State Standard 17509-72. Reliability of machine building products. Data gathering and processing system. Methods of determining the spot estimates of reliability indexes with respect to the observation results.



Average failure distribution for the UChPU by causes of occurrence.

1. During the process of the investigation under industrial conditions of the reliability of the UChPU, quantitative estimates of the reliability indexes were discovered. The work time per failure and the repair time of the UChPU correspond to the values regulated by the technical specifications, and they are on the level of the best foreign models.

2. The failure distribution was made with respect to causes of their occurrence (see the figure). At the enterprises with a high level of technical servicing of the UChPU the operational failures occurring as a result of violation of the established rules or operating conditions amount to 34%. At the enterprises with low level of technical servicing 90% of all of the failures are connected with violation of the maintenance or repair rules.

In order to increase the effectiveness of using the UChPU it is necessary to perform a set of measures with respect to organizing an effective technical servicing system.

3. A significant part (42%) of the failures fall to the lot of the kit elements, the basic failures of which are as follows: failure of the microcircuits 38.6%; defects of the KT805 transistors 6.4% and the KT315 transistors 8.8%; sticking of the RSM-2 relay contacts 2.2% and the RES-10, 5.1%; deficiencies of the optrons 2.4%; poor commutation in the RPPG2-48 plug 6.2%.

4. The failure distribution was made with respect to the assemblies and units of the UChPU. The majority of failures (43%) on the "Kontur 2PT-71" UChPU are connected with failures of the input device. For the UChPU on a microelectronic base, as a result of somewhat different structural design of the protective door in the presence of the "frame retrieval" mode, the number of the indicated failures is appreciably lower and does not stand out among the failures with respect to the remaining modules of the UChPU.

5. A qualitative estimate of the deficiencies of the UChPU on digital and microelectronic bases and also with respect to types of machine tools joined to them was obtained. Suggestions and proposals of the users with respect to improving the UChPU were gathered and analyzed simultaneously, and recommendations were made with respect to improving their reliability.

6. On the basis of the operating experience in 1976-1977, corrective action was developed, and the UChPU was modified, permitting an increase in the time worked per failure of the N22 and N33 digital program control devices.

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